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BUREAU OF MINES MINERALS YEARBOOK

The Mineral Industry of Arizona



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This publication is a chapter from the current Bureau of Mines Minerals Yearbook, comprising *Volume I, Metals and Minerals; Volume II, Area Reports: Domestic; Volume III, Area Reports: International*. The separate volumes of the Yearbook are sold by the Superintendent of Documents, Washington, D.C. 20402.

The Mineral Industry of Arizona

This chapter has been prepared under a Memorandum of Understanding between the Bureau of Mines, U.S. Department of the Interior, and the Arizona Department of Mines and Mineral Resources for collecting information on all nonfuel minerals.

By Michael N. Greeley¹

Arizona's nonfuel mineral production rose in 1987 to \$1.8 billion. This represents an increase of more than \$200 million or about 15% over that of 1986. Containing diversified mineral resources, the State ranked second nationally in the value of its nonfuel production.

Leading the Nation in the production of

copper, Arizona is also among the top producers of bentonite, cement, gem stones, lime, molybdenum, rhenium, sand and gravel, silver, and sulfuric acid. Copper was the principal commodity produced in terms of value, accounting for almost \$1.4 billion or about 78% of the total nonfuel mineral value produced in the State.

Table 1.—Nonfuel mineral production in Arizona¹

Mineral	1985		1986		1987	
	Quantity	Value (thousands)	Quantity	Value (thousands)	Quantity	Value (thousands)
Clays thousand short tons . . .	186	\$1,503	201	\$1,366	218	\$1,905
Copper (recoverable content of ores, etc.) . .						
metric tons	796,556	1,175,995	789,175	1,149,193	764,148	1,389,771
Gem stones	NA	*2,700	NA	2,533	NA	3,000
Gold (recoverable content of ores, etc.) . .						
troy ounces	52,053	16,535	W	W	95,240	42,663
Gypsum thousand short tons . .	251	1,926	260	1,820	W	W
Lead (recoverable content of ores, etc.) . .						
metric tons	581	244	W	W		
Lime thousand short tons . . .	476	21,226	505	21,016	546	21,932
Molybdenum thousand pounds . .	24,125	63,389	29,382	75,607	W	W
Perlite short tons	W	W	W	W	49	1,361
Pumice thousand short tons . .	W	2	2	30	1	7
Sand and gravel (construction) . . . do . .	*37,000	*118,000	40,468	140,084	*38,100	*141,300
Silver (recoverable content of ores, etc.) . .						
thousand troy ounces	4,885	30,007	[†] 4,506	[†] 24,649	3,667	25,706
Stone (crushed) thousand short tons .	5,929	23,111	*5,600	*25,100	7,712	33,999
Combined value of cement, pyrites (1985, 1987), salt (1986-87), sand and gravel (industrial), stone (dimension), and values indicated by symbol W	XX	95,447	XX	[†] 118,505	XX	129,399
Total	XX	1,550,085	XX	[†] 1,559,823	XX	1,791,043

*Estimated. [†]Revised. NA Not available. W Withheld to avoid disclosing company proprietary data; value included with "Combined value" figure. XX Not applicable.

¹Production as measured by mine shipments, sales, or marketable production (including consumption by producers).

Table 2.—Nonfuel minerals produced in Arizona in 1986, by county¹

County	Minerals produced in order of value
Apache	Clays, sand and gravel (construction)
Cochise	Copper, sand and gravel (construction), gold, silver
Cocino	Sand and gravel (construction)
Gila	Copper, molybdenum, sand and gravel (construction), clays
Graham	Sand and gravel (construction), pumice
Greenlee	Copper, gold, silver, molybdenum, sand and gravel (construction)
La Paz	Sand and gravel (construction)
Maricopa	Sand and gravel (construction), salt, gold, clays, silver
Mohave	Sand and gravel (construction), gold
Navajo	Sand and gravel (construction)
Pima	Copper, cement, molybdenum, sand and gravel (construction), silver, gold, clays, lead
Pinal	Copper, sand and gravel (construction), molybdenum, gold, silver, gypsum, perlite, clays
Santa Cruz	Sand and gravel (construction)
Yavapai	Copper, cement, lime, molybdenum, sand and gravel (construction), silver, gypsum, clays, gold
Yuma	Sand and gravel (construction)
Undistributed ²	Stone (crushed), gem stones

¹No production of nonfuel mineral commodities was reported for counties not listed.

²Data not available by county for minerals listed.

Trends and Developments.—In general, the mining industry began to show signs of improvement in 1987. In a concerted effort to cut costs, the copper producers continued to restructure their organizations and improve productivity. Acquisition was common through purchase of known copper reserves and active production. Costly smelter operations were either closed or modernized and relatively inexpensive hydrometallurgical plants were installed or enlarged.

Almost one-fifth of all copper produced in the State was recovered by leaching oxide ores and low-grade dumps. This low-cost technology has received increasing use by the copper companies.³ The production of copper by cementation decreased more than 30% in 1987.

These company policies and developments laid the foundation for higher profits and dividends when the price of copper began to rise. Miners received voluntary *disbursements* and bonuses mandated by labor contracts negotiated in 1986. Over \$17 million was distributed by the copper companies to approximately 6,100 workers for 1987.

Prospectors and mine developers continued to show an increased interest in the gold potential of Arizona. Claim staking, particularly in the western part of the State, was heavy. Records maintained by the Bureau of Land Management rank Arizona third among the States in the number of active claims for all commodities. Unlike the recent past when gold was recovered principally as a byproduct of copper or silver mines, approximately one-half of the production is now from primary sources.

Production of industrial minerals continued to improve in the State. Interest in clays, gem stones, gypsum, lime, perlite, and salt remained high. There was a marked increase in the production of crushed stone.

Employment.—An annual average of 11,100 workers was employed in the Arizona mining industry.⁴ This figure, a slight increase over that of 1986, includes workers in the mineral fuels industry. Over 80% of this total work force is in copper exploration and production. The number of miners and other employees in the copper industry, averaging 8,900 during 1987, was reduced as the mining companies continued cost-cutting measures and exported smelting to other States. The smelter at Douglas, owned by the Phelps Dodge Corp., was closed permanently on January 15.

The mining industry of Arizona provided a total income to its workers of \$422.9 million. The copper industry contributed \$254.1 million (60%) to this total. The average weekly earnings of a mining company employee, \$584, were the highest in the State's industrial sector.

Legislation and Government Programs.—The Arizona State Legislature agreed in Senate bill (S) 1317 to provide limited funds to the office of the State Mine Inspector to locate and quantify the danger of mine openings. Attention was to be paid initially to mining districts close to major urban areas.

State legislation (S. 1102) was enacted to create, effective July 1, 1988, the new Arizona Geological Survey in Tucson. This agency was formed by separating the Geologic Branch of the Arizona Bureau of Geology and Mineral Technology from the University of Arizona. The Mineral Technology Branch remained with the university under the administration of the College of Engineering and Mines. The director of the new agency serves officially as the State geologist and is appointed directly by the Governor of the State.

Effective August 17, 1987, new regulations governing certain location requirements when staking lode, placer, and mill-site claims were promulgated by the Arizona State Legislature (S. 1125). The new law requires the location monument of a lode claim to be placed on the center line instead of at a corner. Monumenting requirements have been changed to eliminate the need for end-center monuments on placer and mill-site claims. Additionally, government survey markers are no longer acceptable as a claim monument.

Late in the year, an important decision affecting mine development on State lands was rendered by the Arizona Supreme Court. This decision declared unconstitutional the current law that sets a flat royalty rate paid by miners who operate on trust lands leased from the State. Until appeals are filed and decisions made in the courts or new legislation is passed or both, the status of mineral leases on State lands is thrown into uncertainty. As a further consequence, mineral explorers are reluctant to obtain new prospecting permits on State lands.

In 1987, the U.S. Congress approved a proposal submitted by the University of Arizona to share the cost of establishing the Center for Advanced Studies for Copper Recovery and Utilization. The Federal share is \$4 million. Primary objectives of the research are threefold: (1) in situ copper leaching, (2) recovery of byproduct copper leach solution, and (3) use of copper and byproduct in the preparation of high-tech materials. The research will be conducted in Tucson under the direction of the Department of Materials Science and Engineering, College of Engineering and Mines.

The Congress also directed the U.S. Bureau of Mines to evaluate several buried, predominantly oxide, copper deposits in Arizona for their amenability to in situ leach-

ing. In situ leaching was identified by the Bureau as a modern development in technology that may have wide application for lowering costs, increasing productivity, and reducing environmental pollution within the mining industry. Essentially all of 1987 was used to develop and prepare a manual of generic in situ copper mine design and to examine several proposed sites for field testing.

An additional project of the Bureau was to conduct research on solution flow modeling and detection. A hydrologic program entitled MINFLO was developed and tested at the in situ leach operation at the San Manuel Mine (Pinal County). The leach solutions are injected, via wells drilled from the surface, into rubbled oxide ore. Leachate is recovered in underground workings. The MINFLO model was applied to analyze flow characteristics of the broken ore mass and volume discrepancies between injected and recovered solutions.

During the year, the Bureau issued two open file reports addressing mineral land assessments in Arizona. These reports summarized mineral evaluations of wilderness study areas (WSA) under the jurisdiction of the Bureau of Land Management. Base and precious metal anomalies were described in the Ragged Top WSA of Pima County.

The Arizona Department of Mines and Mineral Resources published "Arizona Mineral Development, 1984-86" and a revised "Arizona Industrial Minerals." The Arizona Bureau of Geology and Mineral Technology, Geologic Branch, published "Proceedings of the 21st Forum on the Geology of Industrial Minerals," "Geologic Diversity of Arizona and Its Margins," and "Compilation of Radiometric Age Determinations in Arizona." This State agency also issued an open file report entitled "Summary of a Workshop on the Search for Unconventional Ore Deposits in Arizona."

REVIEW BY NONFUEL MINERAL COMMODITIES

METALS

Copper.—Arizona continued to rank first in the Nation in copper production with over 60% of the total domestic output. More than 1.6 billion pounds was produced in 1987 and the red metal accounted for more than three-fourths of the State's nonfuel mineral value. There were 12 principal copper mine operations. Although 1987 copper production in Arizona decreased slight-

ly, increasingly tight supplies resulted in a dramatic rise in prices during the second half of the year. There was an ultimate 21% rise in the annual value of copper produced as compared with that of 1986.

Several steps were taken by the producers to reduce costs and improve productivity and competitiveness during one of the longest downturns ever experienced in the industry. In addition to cutting the work force in Arizona by more than one-half, the in-

dustry eliminated the automatic cost-of-living adjustment and reduced benefit provisions. Working from this base of labor-related savings established in the early to

mid-1980's, firms rapidly initiated corporate restructuring and innovative mining and metallurgical technology.

Table 3.—Arizona: Material handled and copper produced at 16 leading copper open pit and underground mines

Mine	Ore mined (thousand metric tons)		Waste material removed (excluding material placed in leach dumps) (thousand metric tons)		Material placed in leach dumps (thousand metric tons)		Total copper produced ¹ (metric tons)	
	1986	1987	1986	1987	1986	1987	1986	1987
OPEN PIT								
Morenci	W	36,149	NA	--	NA	--	W	247,756
Ray	9,874	10,859	--	--	20,949	21,562	90,848	97,692
Pinto Valley	20,172	W	79,995	NA	177,664	NA	81,664	W
Sierrita	² 26,928	26,481	² 6,413	8,957	² 494	1,168	² 80,737	71,654
Bagdad	17,919	20,178	5,457	7,320	4,403	8,258	78,853	82,862
Inspiration	429	W	13,567	NA	12,862	NA	51,021	W
Mission Complex	2,663	² 6,315	1,686	² 8,619	--	--	19,285	² 38,322
Eisenhower	3,559	(²)	3,570	(²)	--	(²)	16,738	(²)
Pima	1,410	(²)	1,198	(²)	--	--	12,678	(²)
San Manuel	6,103	6,749	10,343	10,448	6,103	6,165	9,945	23,573
San Xavier	1,374	947	763	797	--	--	7,196	4,492
Miami	--	W	--	NA	--	NA	3,451	W
Silver Bell	--	--	--	--	--	--	3,244	4,954
Johnson	--	--	--	--	--	--	2,211	--
Esperanza	(²)	--	(²)	--	(²)	--	(²)	--
Mineral Park	--	--	--	--	--	--	--	2,101
UNDERGROUND								
San Manuel	16,332	16,352	791	--	--	--	92,126	86,616
Cyprus Casa Grande ⁴	--	--	--	--	--	--	3,221	1,045

NA Not available. W Withheld to avoid disclosing company proprietary data.

¹Gross metal content.

²In 1986, owing to change of ownership, Sierrita and Esperanza have been combined to form one unit. All future reporting will reflect this change.

³In 1987, owing to a company change in reporting, Mission, Eisenhower, and Pima have been combined to form one unit. All future reporting will reflect this change.

⁴Formerly Lakeshore.

Phelps Dodge Corp., the largest producer of copper in Arizona and in the United States, moved its corporate headquarters from New York City and consolidated much of its executive staff in Phoenix. Cyprus Minerals Co. continued to increase its share of copper production in the State by purchasing the Lakeshore Mine (Pinal County) from Noranda Mines Ltd. and renaming the operation Cyprus Casa Grande. The rapidly expanding firm also established a development unit for metal business near Tucson. This unit is charged with identifying and bringing into production new mining ventures in the Southwestern States and in Mexico. Negotiations to acquire the idle Twin Buttes Mine in Pima County from Park Corp. were begun toward yearend. Magma Copper Co., the second-largest copper producer in Arizona, became independent during the year when it was released by its parent, Newmont Mining Corp.

ASARCO Incorporated continued to consolidate its holding adjacent to the Mission Mine (Pima County) by acquiring the interest held by the Anamax Mining Co. in the Palo Verde (Eisenhower) Mine.

Having recognized the trend to fewer suppliers of smelter feed, Asarco continued to increase its self-reliance by initiating a \$13 million expansion at the Mission Complex. Most of this expansion was to be brought about through modernization of the concentrator. When completed, it will increase production capacity by 46%. Expansion and modernization of Magma's San Manuel facility continued through 1987. The processing capacity of the solvent extraction-electrowinning (SX-EW) plant will be increased to 65,000 short tons annually. Construction of a new oxygen flash furnace and smelter retrofit proceeded rapidly during the year. The capital expenditure plan, requiring \$267 million, also

included modernization of the concentrator, expansion of the refinery, and development of the deep Kalamazoo ore deposit.

Among Arizona's producers, Inspiration Consolidated Copper Co. was the only one to employ solvent extraction for a full year to recover its entire output of copper. Toward the end of the year, the company announced plans to expend \$25 million to increase SX-EW capacity by 25%. Phelps Dodge also confirmed acceptance of this low-cost means of production by completing construction of a new \$92 million SX-EW facility at Morenci. This facility consists of three solvent extraction units that supply one tankhouse at the rate of 30,000 gallons per minute. The complex, the largest of its type in the United States, is designed to produce 50,000 short tons of cathode copper annually.

Interest in copper deposits that may be amenable to treatment by solvent extraction continued to increase during the year. These deposits are relatively abundant in Arizona and a number of them were investigated. Phelps Dodge estimated its Cochise deposit near Bisbee to contain about 170 million tons averaging 0.5% copper. The company initiated studies to determine if this copper mineralization could be mined economically. The Kocide Chemical Co. continued development, at a reduced rate, of the VanDyke Mine in Gila County. Plans call for this chiefly oxide copper deposit to be solution-mined initially at a rate of 600,000 pounds per month of copper. Cement copper produced at the mine site will be converted to copper sulfate for agricultural fertilizers.

Gold.—Between the advent of World War II and the mid-1980's, the bulk of gold production in Arizona was a byproduct of copper mining. In 1987, primary ores of gold became an important source of this important metal.

The most significant new mine brought into production during the year was the Copperstone Mine in La Paz County. Development of this open pit property by Cyprus Copperstone Gold Corp. required about \$14 million in capital expenditures; designed capacity is about 60,000 troy ounces per year.

There were several smaller surface mines operating in the State that produced gold in 1987.⁴ J. Devins Resources continued its operation at the U.S. Mine in Maricopa County with gold recovered from ore heaps by cyanide leaching. Heap leaching was also used at the Portland Mine in Mohave Coun-

ty. Although mining operations at the Portland Mine were terminated in June, Western States Minerals Corp. continued leaching through yearend, reportedly producing about 300 troy ounces of gold per month.

Important underground gold mines in Yavapai County included the Gladiator-War Eagle Mine operated by Nor-Quest Arizona Inc., the Congress Mine under development by Echo Bay Mines, and the McCabe Mine being developed by the Stan West Mining Corp. The Nor-Quest ores were milled at a rate of approximately 100 tons per day and the gold concentrates shipped to the Cominco Ltd. smelter in British Columbia. Echo Bay completed a 3,300-foot decline ramp to development ore having a high silica content and reportedly averaging 0.3 troy ounce of gold per short ton. The ore to serve as a flux was to be shipped to the Phelps Dodge smelter at Playas, NM. Stan West Mining continued to develop its gold-bearing, multimetal McCabe Mine in Yavapai County. This relatively deep mine was being prepared to supply a concentrator, also under construction, with a daily feed of 500 short tons.

Placer gold was produced intermittently at several localities. The principal operations were in the counties of Maricopa, Pima, and Yavapai. Tailings shipped as copper-smelter flux also provided minor gold production to the State total.

Although western Arizona received the most intense exploration for gold, extensive investigation and development occurred throughout much of the State. Among the particularly active lode sites were the Gold Bug, Pilgrim, and Van Deeman Mines in Mohave County; the United Verde Extension and Vulture Mines in Yavapai County; the Mystic Mine in Maricopa County; the Gold Prince Mine in Cochise County; and the Margarita Mine in Santa Cruz County.

Molybdenum.—During 1987, the third-largest producer of molybdenum in the Nation was Arizona. All of the metal is recovered as a coproduct or byproduct of copper production.

Despite the relatively minor change in copper production during 1987, compared with that of 1986, the amount of molybdenum recovered during this year decreased over 50%. Of the five mines producing molybdenum in the State, the Cyprus Sierita operation was the largest.

Silver.—Production of silver in Arizona declined almost 19% from the total of last year. Most of this reduction occurred in the

Pima mining district southwest of Tucson. Because of a higher, average annual price, however, the total value of the State's silver production increased.

In Arizona, the recovery of silver is generally dependent on the production of copper since it is chiefly a byproduct of copper refining. In addition to important amounts of silver recovered from mill tailings that are fed by several properties to copper smelters, substantial silver is reported from the silica-flux ore mined underground at the Ash Peak Mine in Greenlee County. This mine produced material averaging from 5 to 6 troy ounces of silver per short ton at a rate of about 200 short tons per day. The Reymert Mine of Pinal County produced similar-grade fluxing ore at a rate of about 1,000 short tons per week. Tailings produced by a recent operator at the Contention Mine of Cochise County were washed to recover residual coproducts of silver and gold. Capacity of the plant was about 40 to 60 short tons per hour.

Other Metals.—The Sierrita Mine in Pima County was the only domestic producer of rhenium in 1987. The metal, occurring as a trace element in molybdenite, is recovered as ammonium perrhenate by roasting the molybdenum concentrates. The relatively small, but high-grade, deposits of uranium in northern Arizona were the source of about 40% of U.S. production during the year. Five mines, located in Coconino and Mohave Counties, were either in production or under development by Energy Fuels Nuclear Inc. With the exception of trace metals recovered at copper refineries, there was no recorded production of other metals in the State.

INDUSTRIAL MINERALS

Cement.—In 1987, cement production represented a significant percentage of the State's total nonfuel mineral value. This production ranks it close to the top third of all the States. Of the two Arizona producers, the largest annual capacity (1,100,000 short tons) is held by Arizona Portland Cement Co. During the year, the Phoenix Cement Co., a division of Gifford-Hill & Co., was sold to the Salt River Pima-Maricopa Indian Community.

Clays.—In terms of total value, clay mining contributes a relatively small amount to the nonfuel mineral production of Arizona. The industry, however, has grown significantly. Mine production increased about 9% during 1987, with an impressive value in-

crease of over 39%. Enhancing the value is the production of high-quality specialty clays such as swelling and nonswelling bentonite mined in central and northeastern Arizona. The most recently developed bentonite property, the Burro Creek Mine (Yavapai County), began operation in 1987. It shipped a small tonnage of saponite, a magnesium-bearing bentonite, to be used as a viscosifier in paint.

Gem Stones.—Arizona ranked third nationally in the production of gem stones. In addition to its well-known agate, malachite, peridot, petrified wood, and turquoise, the State also produces an unusual blue, fire opal from Santa Cruz County. Arizona's share of national gem stone production was 14% in 1987, a notable decrease from that of 1986.

Lime.—Production of lime in the State increased by about 8% compared with that of 1986. Domestically, Arizona ranks 11th in total production. The State's two limestone quarries and lime plants are owned by Chemstar Inc. Total production capacity is approximately 2,800 tons per day. During 1987, the Nelson plant in Mohave County was equipped with a facility to hydrate lime. Hydrated lime, in competition with cement, is used increasingly as an additive in asphalt pavements to slow aging characteristics and to reduce moisture damage.

Perlite.—There was a sharp increase in perlite production during the year. Two mining firms operated surface pits in eastern Pinal County and supplied a variety of markets out of State. Although Arizona ranked second after New Mexico, its production is relatively small.

Sand and Gravel (Construction).—Construction sand and gravel production is surveyed by the U.S. Bureau of Mines for even-numbered years only. This chapter contains actual data for 1986 and estimates for 1985 and 1987. Data for odd-numbered years are based on annual company estimates.

Arizona ranked among the top five producers of sand and gravel in the United States. Although estimates indicate a decline in production from that of 1986 of almost 6%, the sand and gravel industry was valued at \$141.3 million in 1987. Most production is concentrated in the urban areas of Phoenix and Tucson. Increasing demand, however, occurs in growing areas such as Casa Grande and Sierra Vista.

Stone.—Stone production is surveyed by the U.S. Bureau of Mines for odd-numbered

years only. This chapter contains actual data for 1985 and 1987 and an estimate for 1986. Data for even-numbered years are based on annual company estimates.

During 1987, production of crushed stone in Arizona increased more than 37% over estimated production in 1986. This production was valued at almost \$34 million. There were 27 privately operated stone

quarries and 25 controlled by Government entities. Five firms accounted for over 80% of the private production.

In 1985, the U.S. Bureau of Mines began compiling crushed stone statistics by districts for some States. Table 5 presents end-use data for crushed stone produced in the three Arizona districts depicted in figure 1.

Table 4.—Arizona: Crushed stone¹ sold or used by producers in 1987, by use

(Thousand short tons and thousand dollars)

Use	Quantity	Value
Coarse aggregate (+ 1-1/2 inch): Filter stone	W	1,178
Coarse aggregate, graded: Concrete aggregate, coarse	358	679
Fine aggregate (-3/8 inch): Screening, undesignated	81	241
Coarse and fine aggregates:		
Graded road base or subbase	376	1,078
Unpaved road surfacing	368	1,937
Terrazzo and exposed aggregate	387	1,462
Other construction ²	1,993	11,015
Chemical and metallurgical:		
Cement manufacture	2,116	7,819
Flux stone	(³)	120
Special: Other unspecified ⁴	1,655	8,391
Total ⁵	7,712	33,999

W Withheld to avoid disclosing company proprietary data; included with "Other construction."

¹Includes limestone, dolomite, marble, granite, sandstone, and volcanic cinder and scoria.

²Includes riprap and jetty stone, bituminous aggregate (coarse), stone sand (concrete), stone sand (bituminous mix or seal), combined coarse and fine aggregates, and crusher run or fill or waste and data indicated by symbol W.

³Withheld to avoid disclosing company proprietary data; included with "Special: Other unspecified."

⁴Includes roofing granules, production reported without a breakdown by end use and estimates for nonrespondents.

⁵Data may not add to totals shown because of independent rounding.

Table 5.—Arizona: Crushed stone¹ sold or used by producers in 1987, by use and district

(Thousand short tons and thousand dollars)

Use	District 1		District 2		District 3	
	Quantity	Value	Quantity	Value	Quantity	Value
Coarse aggregate (+ 1-1/2 inch) ²	--	--	W	W	W	W
Coarse aggregate, graded ³	(⁴)	(⁴)	W	W	W	W
Fine aggregate (-3/8 inch) ⁵	--	--	35	60	127	699
Coarse and fine aggregates ⁶	--	--	254	1,863	1,024	3,785
Other construction	--	--	25	107	2,122	10,570
Chemical and metallurgical ⁷	(⁴)	(⁴)	30	120	(⁸)	(⁸)
Special ⁹	--	--	--	--	(⁸)	(⁸)
Other miscellaneous	--	--	--	--	1,297	4,290
Other unspecified ¹⁰	1,771	6,822	179	696	837	4,947
Total	1,771	6,822	523	2,846	5,407	¹¹ 24,290

W Withheld to avoid disclosing company proprietary data; included with "Other construction."

¹Excludes 10,950 short tons, valued at \$42,000 not reported by county.

²Includes riprap and jetty stone and filter stone.

³Includes concrete aggregate (coarse) and bituminous aggregate (coarse).

⁴Withheld to avoid disclosing company proprietary data; included with "Other unspecified."

⁵Includes stone sand (concrete), stone sand (bituminous mix or seal), and fine aggregate (screen).

⁶Includes graded road base or subbase, unpaved road surfacing, terrazzo and exposed aggregate, and crusher run or fill or waste.

⁷Includes cement manufacture and flux stone.

⁸Withheld to avoid disclosing company proprietary data; included with "Other miscellaneous."

⁹Includes roofing granules.

¹⁰Includes production reported with a breakdown by end use and estimates for nonrespondents.

¹¹Data do not add to total shown because of independent rounding.

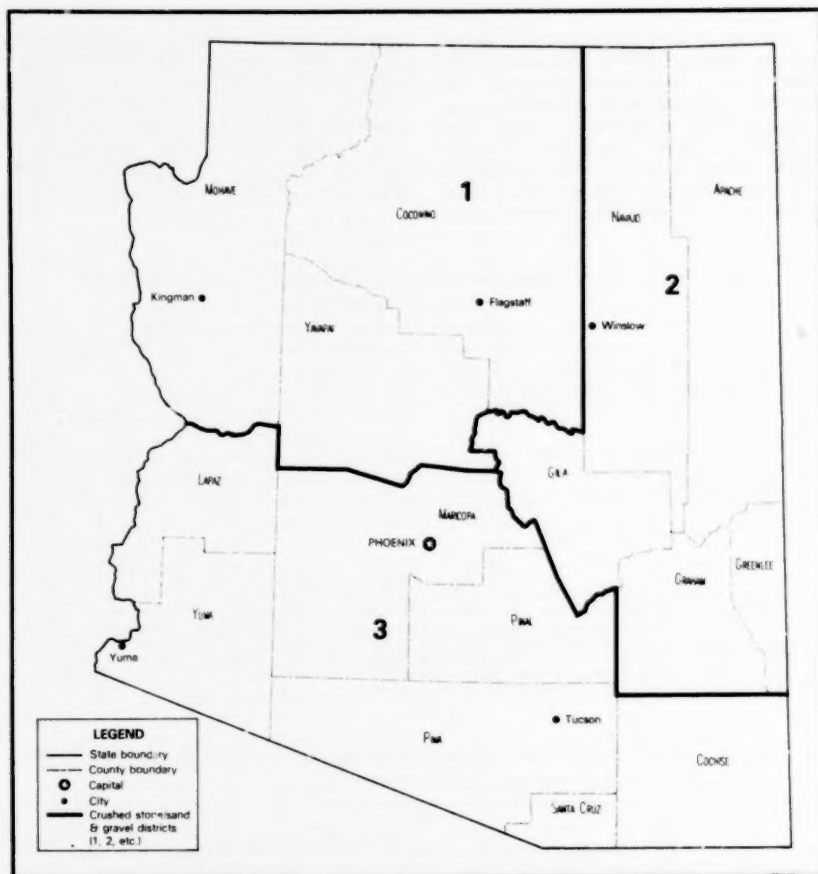


Figure 1.—Aggregate-producing districts in Arizona.

Other Industrial Minerals.—Although the combined value of a number of other commodities produced in Arizona is less than 1% of the total, the commodities are important to the citizens and the economy of the State. These industrial mineral products include diatomaceous earth, gypsum, pumice, pyrites, salt, industrial sand, dimension stone, sulfuric acid, and zeolites.

Diatomite was mined and processed at the Whitecliffs Mine in Pinal County. Production for industrial filler markets began in 1986; plant capacity is rated at 75 short tons per day.

The gypsum industry in Arizona, supporting three mining companies, produced for a variety of agricultural and manufacturing uses. Pumice, produced in Coconino, Gila, and Yavapai Counties, was used in lightweight masonry, textile abrasives, and pet waste absorbent. Pyrite concentrates were obtained from the Magma Mine in Pinal County and sold to pigment markets.

Salt was solution-mined from the Luke deposit in Maricopa County. The salt is marketed principally to agricultural and industrial users. After the salt is removed, the underground solution cavities are used to store butane and propane.

Continued production of well-rounded and well-sorted quartz sand (industrial sand) occurred at the Houck Mine in Apache County. This relatively high-value commodity has been used chiefly for hydraulic fracturing applications.

Sulfuric acid, as a byproduct of metal smelters and roasters in the United States, was produced in greatest quantity at Arizona's copper smelters. The total, 1,199,701 short tons, produced in this manner represented over 35% of the Nation's byproduct sulfuric acid.

W. R. Grace and Co. produced exfoliated vermiculite at its plant in Maricopa County. The crude vermiculite was shipped into the processing facility from out of the State,

and the final product was used primarily in fireproofing, insulation, and aggregate applications.

Two relatively small industrial mineral industries in Arizona that may eventually become larger are the production and marketing of dimension stone and zeolites. The State has large reserves of both and the diversity of dimension stone is impressive. Approximately six companies quarry dimension stone and supply various users nationwide. Similarly, as technology develops new markets for the zeolite group of

minerals, the Bowie chabazite deposit (and others like it) will increase its production. In 1987, four mining firms shipped from this deposit, which straddles the Cochise-Graham County line.

¹State Mineral Officer, Bureau of Mines, Tucson, AZ.

²Beard, R. R. The Primary Copper Industry of Arizona in 1987. Arizona Dep. Mines and Miner. Resour. (Phoenix), Feb. 1989, 75 pp.

³Leaming, G. F. The Copper Industry's Impact on the Arizona Economy 1987. West. Econ. Anal. Cent. (Marana, AZ), June 1988, 32 pp.

⁴Mine files of the Arizona Department of Mines and Mineral Resources (Phoenix).

Table 6.—Principal producers

Commodity and company	Address	Type of activity	County
Cement:			
Arizona Portland Cement Co., a division of California Portland Cement Co., a subsidiary of CalMat Co. ^{1 2}	Box 338 Rillito, AZ 85654	Quarry and dry-process, 4-rotary-kiln plant.	Pima.
Salt River Pima-Maricopa Community (formerly Phoenix Cement Co.) ^{1 2}	Box 428 Clarkdale, AZ 86324	Quarry and dry-process, 3-rotary-kiln plant.	Yavapai.
Cinder (volcanic):			
Flagstaff Cinder Sales Inc.	Old Highway 66 Box 2796 Flagstaff, AZ 86003	Quarry	Coconino.
Superite Builders Supply, a subsidiary of U.S. Industries Inc.	Box 40159 Flagstaff, AZ 86004	Open pit mine and crushing plant.	Do.
Clays:			
Building Products Co.	4850 West Buckeye Rd. Phoenix, AZ 85043	Open pit mines	Navajo and Yavapai.
Clinton-Campbell Contracting Inc. (formerly Phoenix Brick Yard)	1814 South 7th Ave. Phoenix, AZ 85007	do	Maricopa and Pima.
Harshaw/Filtrol Partnership of Kaiser Aluminum & Chemical Corp. and Chevron Corp.	Box 155 Sanders, AZ 86512	Surface strip mine	Apache.
McKusick Mosaic Co.	Route 1, Box 35-D Globe, AZ 85501	Surface mine	Gila.
United Dessicants, a division of United Catalyst Inc.	Box 32370 Louisville, KY 40232	Surface strip mine	Apache.
Copper:			
ASARCO Incorporated:			
Hayden Unit	Box 98 Hayden, AZ 85235	Smelter and acid plant ...	Gila.
Mission Complex ^{3 4 5}	Box 111 Sahuarita, AZ 85629	Open pit mines and mill ...	Pima.
Ray Unit ^{3 5 6}	Box 9 Hayden, AZ 85235	Open pit mine, leach dumps, precipitation, solvent extraction-electrowinning plants.	Gila and Pinal.
Silver Bell Unit	Marana, AZ 85653	Leach dumps and precipitation plant.	Pima.
Cyprus Metals Co., a division of Cyprus Minerals Co.:			
Cyprus Bagdad Copper Co. ^{5 6}	Box 245 Bagdad, AZ 86321	Open pit mine, mill, dump leach, solvent extraction-electrowinning plant.	Yavapai.
Cyprus Casa Grande	Box C-9 Casa Grande, AZ 85222	In situ mine and solvent extraction-electrowinning plant.	Pinal.
Cyprus Mineral Park	Box 6249 Kingman, AZ 86401	Dump leach and precipitation plant.	Mohave.
Cyprus Sierrita Corp. ^{3 5 6}	Box 527 Green Valley, AZ 85622	Open pit mine, mill, leach dumps, precipitation plant, solvent extraction-electrowinning plant.	Pima.
Inspiration Consolidated Copper Co.	Box 1559 Claypool, AZ 85532	Open pit mines, mill, dump leaching, precipitation and solvent extraction-electrowinning plants, smelter, sulfuric acid plant, refinery, continuous-cast rod plant.	Gila.

See footnotes at end of table.

Table 6.—Principal producers—Continued

Commodity and company	Address	Type of activity	County
Copper—Continued			
Magma Copper Co.: San Manuel Div. 1 3 5 6 7	Box M San Manuel, AZ 85631	Underground mine, mill, in situ and heap leaching, solvent extraction- electrowinning, acid plant, smelter, refinery, continuous cast copper rod plant.	Pinal.
Pinto Valley Div. -----	Box 100 Miami, AZ 85539	Open pit mine, mill, leach dumps, in situ leach, sol- vent extraction-elec- trowinning plant.	Gila.
Phelps Dodge Corp.: Corporate Headquarters -----	2600 North Central Ave. Phoenix, AZ 85004-3015		
Copper Queen Branch -----	Highway 92 Bisbee, AZ 85603	Leach dumps, in-place leaching, precipitation plant.	Cochise.
Morenci Branch ^{3 5 6} -----	Morenci, AZ 85540 -----	Open pit mine, mills, dump leach, precipitation and electrowinning plants.	Greenlee.
Diatomite: Whitecliffs Industries -----	460 West Roger Rd. Suite 101 Tucson, AZ 857055	Surface mine and plant. ---	Pinal.
Gold: Cyprus Copperstone Gold Corp. ---	Box A1 Parker, AZ 85344	Open pit mine, agitation leach.	La Paz.
Nor-Quest Arizona Inc. -----	Box 416 Crown King, AZ 86343	Underground mine and concentrator.	Yavapai.
Gypsum: National Gypsum Co.: Gold Bond Building Products Div. Winkelman Gypsum Pit -----	Box 20863 Phoenix, AZ 85036 Star Route, Box 3990 Winkelman, AZ 85292	Plant. ----- Open pit mine and crushing plant.	Maricopa. Pinal.
Pinal Gypsum Co. -----	Box 99 Coolidge, AZ 85228	Open pit mine -----	Do.
Superior Companies ^{1 2} -----	1700 North 7th St., No. 5 Phoenix, AZ 85005	Quarries and plant -----	Apache, Pinal, Yavapai.
Lime: Can-Am Corp., Paul Lime Div., a subsidiary of Chemstar Inc. ³ Chemstar Inc. -----	Drawer T Douglas, AZ 85607 Box 197 Peach Springs, AZ 86434	Quarry and 3 lime kilns -- Quarries and plant -----	Cochise. Yavapai.
Perlite: Harborlite Inc. -----	Box 960 Superior, AZ 85273	Open pit mine and plant --	Pinal.
Nord-Sil-Flo Inc., a subsidiary of Nord Resources Corp. -----	Box 127 Superior, AZ 85273	-----do -----	Do.
Pumice: Arizona Tufflite Inc. -----	2432 West Peoria Phoenix, AZ 85029	Open pit mine -----	Coconino.
Gila Valley Block Co. -----	Box 465 Safford, AZ 85546	-----do -----	Graham.
Salt: Morton Salt Div., a subsidiary of Morton Thiokol Inc. -----	13000 West Glendale Ave. Glendale, AZ 85307-2408	Solution mining and solar evaporation.	Maricopa.
Sand and gravel: Arizona Silica Sand Co. -----	Box 108 Houck, AZ 86506	Open pit mine -----	Apache.
Baseline Materials Inc. -----	38353 Schnepf Rd. Queen Creek, AZ 85242	Pits. -----	Maricopa.
Blue Circle West Inc. -----	2625 South 19th Ave. Phoenix, AZ 85009	-----do -----	Do.
CalMat Co. of Arizona, a subsidiary of California Portland Cement Co., a subsidiary of CalMat Co. Century Materials -----	1801 East University Dr. Box 52012 Phoenix, AZ 85036 2156 East 1st St. Box 3175 Tempe, AZ 85281	Pits and plants ----- Pits. -----	Do. Do.
Granite Construction Co. -----	4115 East Illinois Box 27557 Tucson, AZ 85726	Pits and plants -----	Pima.
Mesa Materials Inc. -----	3410 North Hugley Rd. Mesa, AZ 85205	Pits. -----	Maricopa.
Phoenix Redi-Mix Co. -----	3635 South 43d Ave. Phoenix, AZ 85009	-----do -----	Do.
Salt River Sand & Rock -----	Box 728 Mesa, AZ 85211	-----do -----	Do.

See footnotes at end of table.

Table 6.—Principal producers —Continued

Commodity and company	Address	Type of activity	County
Sand and gravel —Continued			
Tanner Companies	3640 South 19th Ave. Box 52124 Phoenix, AZ 85072	Pits and plants	Coconino, La Paz, Maricopa, Pima, Pinal, Yavapai, Yuma
Union Rock & Materials Corp	2800 South Central Ave. Box 8007 Phoenix, AZ 85066	do	Maricopa and Pima
Stone:			
Crushed:			
Andrada Marble Co	4901 East Drexel Rd. Tucson, AZ 85706	Quarry	Pima
Arizona Granite	7401 West Villa Rita Dr. Peoria, AZ 85345	do	Maricopa
Madison Granite Supplies	7050 Grand Ave. Glendale, AZ 85301	Quarry and plant	Do.
Red Mountain Mining Inc	4250 North Bush Hwy. Mesa, AZ 85205	do	Do.
Scala Granite	East Canyon Dr. Apache Junction, AZ 85220	do	Pinal
Dimension:			
Dunbar Stone Co	Box 246 Ash Fork, AZ 86320	Quarries and plant	Coconino, Maricopa, Mohave, Yavapai
Western States Stone Co	2830 Grand Ave Phoenix, AZ 85017	do	Coconino, La Paz, Maricopa, Mohave, Yavapai
Smelter flux:			
Little Hill Mines Inc	Box 332 Oracle, AZ 85623	Open pit mine	Pinal
Triple Nichol Inc	R.R. 1, Box N123 Globe, AZ 85501	Surface and underground mines	Gila and Pinal
Vermiculite (exfoliated):			
W. R. Grace & Co., Construction Products Div.	4220 West Glenrosa Phoenix, AZ 85019	Plant	Maricopa
Zeolite:			
GSA Resources	Box 16509 Cortaro, AZ 85652	Surface strip mine	Cochise
Union Carbide Corp	Box 1029 Grand Junction, CO 81502	do	Do.

¹Also clays.²Also limestone.³Also gold.⁴Also lead.⁵Also silver.⁶Also molybdenum.⁷Also lime.